

U.S. Patent Application Serial No. 10/735,886
Response filed April 24, 2006
Reply to OA dated December 23, 2005

REMARKS

Claims 1, 4 - 6 and 18 are currently pending in this patent application, claims 7 - 17 having been withdrawn, and claims 2 and 3 having been canceled without prejudice or disclaimer.

Claims 1 and 18 have been amended in order to more particularly point out, and distinctly claim the subject matter to which the applicants regard as their invention. It is believed that this Amendment is fully responsive to the Office Action dated December 23, 2005.

The Examiner has removed Dubin as a reference in rejecting the claims. However, claims 1, 4 - 6 and 8 continue to be rejected in view of Takata and Brown. The rejections are discussed below.

First, claims 1, 4, 6, and 18 are rejected under 35 USC §103(a) as being unpatentable over Takata (U.S. Patent No. 6,500,675). The applicants respectfully request reconsideration of this rejection.

The applicants' claimed invention, as now recited in claim 1, is directed to a multilayer interconnection structure, which includes a first interconnection layer including a copper interconnection pattern. The copper interconnection pattern has a top principal surface coincident to a top principal surface of the first interconnection layer and filling a trench formed in the first interconnection layer. The

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claimed multilayer interconnection structure further includes an interlayer insulation film formed on the first interconnection layer; a second interconnection layer formed on the interlayer insulation film; a via-hole formed in the interlayer insulation film so as to expose the copper interconnection pattern; and a tungsten plug formed in the via-hole so as to connect the first interconnection layer and the second interconnection layer electrically. As further recited in claim 1, the via-hole has a depth/diameter ratio of 1.25 - 3.0. Also, there is formed a conductive nitride film between an outer wall of the tungsten plug and an inner wall of the via-hole such that the conductive nitride film is defined by an inner wall contacting with the outer wall of the tungsten plug and an outer wall contacting with the inner wall of the via-hole. As further recited in claim 1, the conductive nitride film is formed of a first nitride film and a second nitride film stacked inside the first nitride film, the first nitride film having an outer surface and an inner surface, the outer surface of the first nitride film being in intimate contact with the inner wall of the via-hole, the second nitride film having an outer surface and an inner surface, the outer surface of the second nitride film being in intimate contact with the inner surface of the first nitride film, the inner surface of the second nitride film being in intimate contact with the outer surface of the tungsten plug.

A significant structural arrangement, as now set forth in claim 1, includes a first interconnection layer including a copper interconnection pattern, wherein the copper interconnection pattern has a top principal surface coincident to a top principal surface of the first interconnection layer and filling a trench formed in the first interconnection layer.

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The applicants' claimed invention, as now recited in claim 18, is directed to a semiconductor device, which includes a substrate; and a multilayer interconnection structure formed on the substrate. The claimed multilayer interconnection structure includes a first interconnection layer including a copper interconnection pattern, wherein the copper interconnection pattern has a top principal surface coincident to a top principal surface of the first interconnection layer and filling a trench formed in the first interconnection layer; an interlayer insulation film formed on the first interconnection layer; a second interconnection layer formed on the interlayer insulation film; a via-hole formed in the interlayer insulation film so as to expose the copper interconnection pattern; and a tungsten plug formed in the via-hole so as to connect the first interconnection layer and the second interconnection layer electrically. As recited in claim 18, the via-hole has a depth/diameter ratio of 1.25 - 3.0. Also, there is formed a conductive nitride film between an outer wall of the tungsten plug and an inner wall of the via-hole such that the conductive nitride film is defined by an inner wall contacting with the outer wall of the tungsten plug and an outer wall contacting with the inner wall of the via-hole. Further, in claim 18, the conductive nitride film is formed of a first nitride film and a second nitride film stacked inside the first nitride film, the first nitride film having an outer surface and an inner surface, the outer surface of the first nitride film being in intimate contact with the inner wall of the via-hole, the second nitride film having an outer surface and an inner surface, the outer surface of the second nitride film being in intimate contact with the inner surface of the first nitride film, the inner surface of the second nitride film being in intimate contact with the outer surface of the tungsten plug.

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A significant structural arrangement, as now set forth in claim 18, includes a first interconnection layer including a copper interconnection pattern, wherein the copper interconnection pattern has a top principal surface coincident to a top principal surface of the first interconnection layer and filling a trench formed in the first interconnection layer.

The applicants submit that Takata fails to teach the above-noted significant claimed structural arrangement directed to the first interconnection being formed by a damascene process. As clearly shown in Takata's Figures 1 and 3 - 15, the pattern 9B underneath the contact plug 12B is formed by patterning a meal film by a dry etching process, which is followed by a deposition process of the interlayer installation film 11 so as to bury the pattern 9B. Because a Cu film cannot be patterned by a dry etching process, the applicants' claimed invention, as recited in each of independent claims 1 and 18, is distinguishable over to the structure of Takata, which is made contradictory to the damascene process, the damascene process being disclosed in the applicants' specification and illustrated in the applicants' Figures 16A - 16L. While Takata describes that the metal layer 9b includes Cu in line 28, column 10 thereof, this statement in Takata cannot be true, in view of the knowledge of the art as explained above.

In order to clarify the distinction of the applicants' claimed invention over the teachings of Takata, the applicants have clarified the feature of damascene process for the first interconnection layer in each of claims 1 and 18. It is submitted that Takata teaches away from the damascene process or damascene structure as set forth in amended claims 1 and 18.

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Furthermore, in view of the different objective of Takata in providing a capacitive element (lines 41 - 50, column 3), which is entirely different from that of the applicants' instant claimed invention, there is no motivation to a person of ordinary skill in the art to derive the applicants' claimed invention, as now set forth in each of claims 1 and 18, from the teachings of Takata.

Also, claims 4 and 6 depend on claim 1, and further limit the scope of claim 1. Thus, at least for the reasons set forth above with respect to claim 1, claims 4 and 6 should now be similarly allowable.

In view of the above, the withdrawal of the outstanding obviousness rejection under 35 USC §103(a) based on Takata (U.S. Patent No. 6,500,675) is in order, and is therefore respectfully solicited.

Secondly, claim 5 is rejected under 35 USC §103(a) as being unpatentable over Takata in view of Brown (U.S. Patent No. 6,306,732). The applicants respectfully request reconsideration of this rejection.

Brown is concerned with providing a diffusion barrier, and not with preventing corrosion of portions of a multilayer interconnection structure when a gas containing F is used in a process for forming the structure, as in the present invention. The teachings of Brown regarding corrosion, alleged by the Examiner, do not however appear to be disclosed in Brown.

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Moreover, Brown does not supplement the above-discussed deficiencies or drawbacks in the teachings of Takata in failing to fully meet the applicants' claimed invention, as now set forth in claim 1 from which claim 5 depends. Thus, the suggested combination of references would still fall far short in fully meeting the applicants' claimed invention.

Accordingly, the withdrawal of the outstanding obviousness rejection under 35 USC §103(a) based on Takata in view of Brown (U.S. Patent No. 6,306,732) is in order, and is therefore respectfully solicited.

In view of the aforementioned amendments and accompanying remarks, claims, as amended, are in condition for allowance, which action, at an early date, is requested.

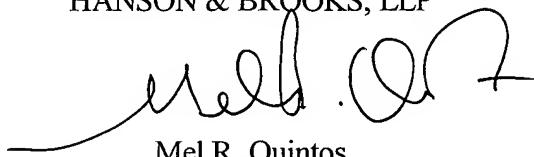
If, for any reason, it is felt that this application is not now in condition for allowance, the Examiner is requested to contact the applicants undersigned attorney at the telephone number indicated below to arrange for an interview to expedite the disposition of this case.

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In the event that this paper is not timely filed, the applicants respectfully petition for an appropriate extension of time. Please charge any fees for such an extension of time and any other fees which may be due with respect to this paper, to Deposit Account No. 01-2340.

Respectfully submitted,

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